TECHNOLOGICAL ADVANCEMENTS IN UNDERWATER RESEARCH

HEARING

BEFORE THE

SUBCOMMITTEE ON OCEANOGRAPHY AND GREAT LAKES

OF THE

COMMITTEE ON MERCHANT MARINE AND FISHERIES HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

ON

THE NEWEST DEVELOPMENTS IN STATE-OF-THE-ART COMMUNICATIONS AND ROBOTICS TECHNOLOGY TO UNDERWATER RESEARCH

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HEARING ON THE NEWEST DEVELOPMENTS IN STATE-OF-THE-ART COMMUNICATIONS AND ROBOTICS TECHNOLOGY TO UNDERWATER RESEARCH

THURSDAY, APRIL 13, 1989

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON OCEANOGRAPHY AND GREAT LAKES,
COMMITTEE ON MERCHANT MARINE AND FISHERIES,
Washington, DC.

The subcommittee met, pursuant to notice, at 12:18 p.m., in Room 1334, Longworth House Office Building, the Hon. Dennis M. Hertel (chairman of the subcommittee) presiding.

Members present: Representatives Hertel, Hughes, Brennan, Saxton, Herger, and Goss.

Staff present: Ray O'Malley, Brian O'Malley, Bill Ashworth, Larry Flick, Lisa Pittman, and Joan Bondareff.

Mr. HERTEL. I call the meeting to order. I apologize that we are having to meet during the lunch hour, but for the rest of the day we count even more conflicts for the members.

OPENING STATEMENT OF HON. DENNIS M. HERTEL, A U.S. REPRESENTATIVE FROM MICHIGAN, AND CHAIRMAN, SUBCOMMITTEE ON OCEANOGRAPHY AND GREAT LAKES

Mr. HERTEL. Good afternoon. Today, our subcommittee sits to review the newest developments in state-of-the-art communications and robotics technology to underwater research.

Our speaker today is Dr. Robert Ballard, Director of the Deep Submergence Laboratory at Woods Hole Oceanographic Institute in Massachusetts, and head of the Jason Project.

Among Dr. Ballard's recent accomplishments in the field of oceanic research include his participation in over 60 deep-sea expeditions, including the use of the deep-diving submersibles Alvin, Archimede, Trieste II, Ben Franklin, Turtle, Cyana, and NR–1.

These expeditions included the first manned exploration of the Mid-Ocean Ridge, the discovery of warm water springs and their unusual animal communities in the Galapagos Rift, the discovery of polymetallic sulfides and high temperature "black smokers," and the recent discovery of R.M.S. Titanic.

My friends, today we are presented with the unique opportunity of contributing to the common stock of public knowledge and information by bringing to light this most intriguing and promising new technology.

When Dr. Ballard and his team depart for the Mediterranean Sea this weekend, it will mark the first time in the history of underwater exploration where a live television broadcast has ever been attempted from the sea floor.

This project will involve the use of robotics, fiber optics, television production, computer science, mechanical and electrical engineering, and satellite communications.

The implications for future use of this new technology reaches not only into the areas of commercial and military exploration, but also presents a valuable learning tool to our country's children, and a very exciting one, too, if I might add.

If the United States is to remain competitive and strengthen its position in the world marketplace, it must be prepared to forge ahead in the fields of science and technology.

Unfortunately, our current educational programs in these areas lags behind those in other industrialized countries, especially in grades 1 through 12.

The Jason Museum Network provides a catalyst for improvement in the areas of teacher training and student interest by bringing the education community up to date on scientific discoveries and areas of current investigation.

The involvement of the children is just tremendous, because I believe it is going to lead to their encouragement, excitement, and life-long basis, and hopefully that many more will make the types of career choices we need for this kind of expanding research for our Nation and the world.

I will now yield to Mr. Saxton for an opening statement.

OPENING STATEMENT OF HON. JIM SAXTON, A U.S. REPRESENTATIVE FROM NEW JERSEY

Mr. SAXTON. I do not have a prepared statement, Mr. Chairman, but I would like to associate myself with the remarks that you made which I think are very appropriate, and right on, and I would like to tell Dr. Ballard how pleased I am, and the minority party is, to have you here today, sir.

It is an honor for us to be able to be here with you and to talk with you about the subject that obviously you are so knowledgeable about. So, welcome, and thank you for being here.

Mr. HERTEL. Mr. Hughes, the Congressman from New Jersey.

Mr. HUGHES. Thank you, Mr. Chairman. I, too, have no prepared text, but I want to congratulate you on convening this hearing, and I am looking forward to Dr. Ballard's testimony. It has got to be one of the most exciting projects I have heard about in a long time. Congratulations. Welcome. Thank you.

Mr. HERTEL. The staff also tells me that Dr. Ballard is going to be diving in the Great Lakes soon after this, so we welcome you to Michigan, whenever you have the occasion. Dr. Ballard, the floor is yours.

STATEMENT OF ROBERT D. BALLARD, DIRECTOR, DEEP SUBMERGENCE LABORATORY, WOODS HOLE OCEANOGRAPHIC INSTITUTE, WOODS HOLE, MASSACHUSETTS

Dr. BALLARD. Well, thank you very much, Mr. Chairman, and Congressmen. I am really excited about being here today to tell you about this project because we are so proud of it, and we will be jumping off Sunday. I am the last of the expedition to get out of town. I shipped out 50 people over last weekend to England to get on the ship. It is on its way to the Mediterranean.

Before getting into that, I wanted just to have some opening comments about why we got involved in this in the first place.

I am a scientist at the Woods Hole Oceanographic Institution on Cape Cod—having been born in Wichita, Kansas where all oceanographers originate from—and Woods Hole, in its association with MIT is one of the finest, if the not the finest oceanographic institution in the world. And I have been there 22 years watching a marvelous cadre of students coming through our doors to receive advanced doctorates in all phases of oceanography and ocean engineering.

And I might say, they are still coming through the door. But over the 22 years that I have been at Woods Hole and associated with this process, I have been somewhat disappointed, and, actually, to a level of alarm now, that the majority of the people walking through my door now to get my staff to educate them are foreign students.

If you look in the fields of hard sciences—of physics, math and chemistry which are the languages of science, and engineering—the majority of the kids in our schools, in American schools today, in those graduate programs, are foreign students.

Now we are literally training the competition, and if America is going to turn its weapons into plowshares, and give up our military edge, if you will, we had better replace it with a mental edge.

And one of the problems is we are not. You know from the recent surveys, that the United States now ranks 17th in scientific literacy in just Western civilization, behind Hungary. And I got mad when I started reading those numbers because I am—you know—what is going on here?

And as I began investigating the problem, like a scientific would just sort of follow it, it took me along an interesting path, and it took me along a path that showed me that the problem of education in this country is not in our graduate schools, where I am sitting, or in our undergraduate schools.

We have the finest graduate schools, the finest colleges in the world. The battle is being lost in junior high and high school. And then I began research on that. I thought, well, let's look at that problem. What is going on here? And I am sure there are a whole variety of issues, and I do not profess, in the limited amount of time I have been looking at this problem, to be the expert.

And I am sure you can get a lot of people here that will say they are, and give you interesting testimony. But I found two factors that upset me, and that this project hopes to address.

One of those is that for some reason—I do not know why, maybe it is fun—the media, book writers, TV writers, cartoon writers—

you turn on your television every day, and whenever you see science portrayed on that tube, or in the movie houses, scientists are presented as nerds. As social misfits, dropouts, if you will, using their intellectual capability to go and hide somewhere and get out of mainstream America.

Now the problem with that is that we create this image, and we all laugh—we have seen "Back to the Future," we have seen "War of the Nerds," "Battle of the Nerds," "The Nerds' Revenue"—and every time I see one of those programs I really get up set, because I would not like someone to come up and call me a nerd. And I have dedicated myself to science, and I believe science is a marvelous endeavor, a fascinating endeavor, and a lot of fun.

The problem is it is not getting across. And what you see in the United States—and I have two boys, one 18 and one 20—and I certainly discovered that when they become 12 I lose them for a while, and they reemerge about 18 and say, oh, my God, Dad, I have got to go to college.

And so there is a period of time, from about 12 to 18 where they are in their own world, and they come home and they need this jacket because Johnnie has this jacket. And what you are seeing in those age groups, from grades 4 through 12, are kids that are trying to fit in.

They are trying to find themselves; they are trying to find themselves within their society. They are looking around for role models. And the last thing a kid in 7th grade wants to do is be a misfit and out of the gang.

And so here they are looking, and they are seeing basketball players making $17,000 a year. I was reading a study the other day that plotted kids' attitudes about why they are going to college, from 1965 to 1985. Well, that is 20 years.

You go in and ask kids, why do you want to go to college? In 1965, the vast majority, over 75 percent, said I go to college because I want to learn about life, I want to learn about myself, I want to—you know—understand the world I was brought into. That is down to about 10 percent now.

Back in 1965 only 10 percent said they want to make money. Now the majority, the vast majority of kid going into college state the reason they are going—to make money, period.

And this trend is not a good trend. It is a long-term trend. It is not something that occurred overnight. Now you are plotting out 20–25 years of data. It is very clear. So there is this problem of perception of what we do and what we are all about, and the role science and technology plays in America's society.

And it is a bad image and a bad wrap we are getting. Now in many respects, there are a lot of nerds in science, and I think that we deserve the rap to some degree. But as we see the development in the American society, we are going to all sorts of groups, whether they are women, or different minority groups, or whatever, and the rules are changing for everybody. As you well know, the rules are changing for everybody and new standards are being imposed, and you cannot be what you were.

And what we are now saying to scientists, and one of the messages—this message is not only to kids, it is directed at my own discipline—and the message reads the following: "It is no longer

good enough to just be smart; you gotta be a team leader, you gotta be an athlete."

And one neat thing about oceanography—it is probably one of your best contact sports in science. And when you go out to sea, in ships and submarines, and you are down to 20,000 feet and something goes wrong, your knowledge level, as an intellect is—you can put that in the can for the moment, you had better get out of there, and you are going to rely upon your physical abilities. You are going to rely upon your ability as a team, to have a team working to save your life. OK.

So oceanography is a really good example that we can take, and that is why I think the oceanographic thrust, in some degree, should be to promote science—not only oceanography—because it is in a unique position to promote science.

And so what happened was is when we—after sort of learning all of this, that I found that factor. Another factor, now my second factor I want to make—and this is another problem because you are going to end up pointing the finger at somebody, and I did last week.

I was in Seattle and I gave a presentation to the National Science Teachers of America. Eleven thousand teachers were there. Here's the message I sent them on that day. I hope they invite me back.

But anyway, what I discovered, as I started doing my homework on science teachers—there are great science teachers in our schools, lots of them, dedicated—all that sort of stuff—bubbling, doing all they can.

But then you start looking at the interesting statistic. The vast majority of our science teachers in junior high school, where the problem is, are life science teachers. They are teaching biology, botany and zoology. They are teaching how to dissect frogs. They are teaching photosynthesis.

And it turns out that the reason for this is that a lot of kids—my youngest son included—wants to be a doctor. You know, everyone has kids that want to be doctors, and it is a noble thing, that no parent turns off that desire.

So these kids go to school and they start preparing themselves for their premed exams. The premed exam is going to come their junior year in college. They take botany, biology, zoology—freshman, sophomore and junior year of college.

They go before that premed exam. The vast majority of them do not make the cut. They then have a choice of retooling themselves, which it is too late at that point, so they graduate out in botany, biology and zoology. They go out in the marketplace and they end up in junior high school teaching science.

The problem is, if you have 85 percent of your science teachers botanists, biologists and zoologists, they do not know physics, chemistry and math.

They are not teaching the language of science in our schools. And as a result our kids, when they come out of high school, they may be bubbling and motivated, but they are untrained, and they are noncompetitive in our own universities.

Now we could start putting in quotas to stop kids from other countries coming to our—that is not the game. The game is to get

our kids in the game. And so what I discovered was that during the Titanic expedition, and certainly since the couple years since we did the Titanic program, we discovered that the vast majority of people fascinated in the Titanic were kids, not people that were around then, but kids.

We have received at Woods Hole thousands and thousands of letters from all over the world, particularly the United States and Canada, about kids who were fascinated about, not so much the Titanic, but how we did it.

Our little R2D2, Jason, Jr., was a thing they quickly attached to because they had seen it in a fanciful way, but what the Titanic expedition proved to be was a "Close Encounters of the Third Kind," but a real one. And that is what turned them on. All of a sudden all the things they had been seeing, and George Lucas, and all of that, and "Star Wars" and everything—all of a sudden a real one happened, and they saw that we were doing underwater Pacman, and they were turned on.

And at that moment, we decided we would start a new project, and we went out into the private sector—and this is what is so marvelous about the Jason project—it is mostly from the private sector.

I went to companies like EDS Corporation, and I got about three minutes into my project and they were bored. Companies like Raytheon. I went out and asked them if they were having trouble recruiting engineers in industry, and industry can say, we cannot get engineers, they are not coming out of our system. So that the Jason project was spawned not as a typical oceanographic expedition like we have done at Woods Hole, funded by the National Science Foundation or the Office of Naval Research to do fundamental research. That is what we are doing. But I think for me, for a while, I am going to shift the focus of my effort, for the next several years, away from graduate students from another country, to kids in junior high school.

Now the concept of the Jason project is really an outgrowth of the technology base we have been developing for the United States Navy.

The United States Navy have funded me over the last 8 years to replace manned presence in the ocean, to be able to eliminate the need for manned submersibles. The reason for that is very simple.

In the deep sea, the average depth of the ocean is 12,000 feet. Just the average. The Titanic sits at the average depth of the ocean. Now when I was diving on the Titanic, physically diving, it took me two and a half hours to get to work in the morning, and two and a half hours to commute home at night. I had a five hour commute to work in a freezing little ball, and only three people in that ball.

As a result, during the course of a dive in a manned submersible, I saw one mile of the ocean. Well, as we sit here today, mankind has seen less than 1/10th of one percent of the deep sea. Less than 1/10th of one percent. We are still at the Lewis and Clark phase of exploration of our planet.

I mean, to me, the most important thing that came out of the space program is when the astronaut looked over his shoulder and saw Earth, and we now know the stress factor this planet is under-

going. Our planet is a living, breathing organism that we are killing, and this generation is the first generation that can kill it.

It was not so important. Previous generations had an appreciation but they could not kill it. But we are killing this planet. Absolutely no doubt about it. And that is why understanding the planet is crucial.

The problem is, most of the planet is under water. Seventy percent of it is down there. Most of it is in total darkness. It is more difficult to go and work in the deep sea than go to the moon. You can get out, walk around; you cannot do that down there. You have got sunlight; you can see. You cannot see down there.

So we had to develop, we had to begin emerging a technology base that would greatly accelerate our rate of exploration.

I mean, Lewis and Clark had the advantage of interviewing Indians when they were going to go exploring. They had some idea. I mean, there are no Indians down there to interview. I mean, you go down there, and every time I open my eyes in the deep sea, I am the first human being in the history of mankind to see that stretch of the Earth. And as I say, at this point, less than 1/10th of one percent has been seen by the human eye.

And we cannot do it in manned submersibles, paying 7000 bucks an hour, to go a few feet. So we had to emerge a new technology base to rapidly accelerate our rate of exploration and to make it cheaper. So the concept of the Argo/Jason—I am going to stand up and show you what it is about. If you could turn off those lights.

[Slide presentation.]

This is the new robotics. As you remember, the Jason, Jr. was a little guy because we used him to go inside. The problem with the little guy was he could not carry a manipulator, he could not do work, and to be able to actually do work and replace a manned submersible, you have to scale up the little guy to—not as big as a manned submersible—but certainly sizeable. It weighs a ton. It lives inside of this guy which we call—I just affectionately call Hugo, which means it's a huge Argo. But anyway, this is the system that goes down to the sea. All right. And it goes down on a cable, and because of a major new breakthrough in technology called fiber optics, we can now vastly increase the amount of imagery that can come up this wire.

When we found the Titanic in 1985, we were using a coaxial cable with copper in it. The problem was you could only—with a copper wire—put up one fuzzy black and white TV signal. So it was not as good as being down in a submarine, to have a black, fuzzy, black-and-white video that you were looking at, when we found the Titanic.

But moving away from copper wires to fiber optics—and this is being built by Rochester right now—we transitioned that technology from Japan, I might say. But anyway, we developed a new transmission link that makes it possible to transmit six broadcast quality television signals to the surface. In other words, you can create a submarine with six windows.

And by being able to do that, to go down with the guy, and you find things with Argo. But then when you find it, you need a very advanced computer control technology base from the oil industry to dynamically hover that ship. Once you hover that ship you hover

that, and once you hover that, Jason can go out and get up close and personal.

This is the replacement of a manned submersible. The beauty of this tech base is that once you create an illusion up here—and the concept is to create the illusion that you are in a—whoops, let me back up here just a second.

Once you are able to take this vehicle system down, you can create a control center up here that simulates a submarine. In other words, we have built a room, that when you go into that room you think you are inside a submarine. You have got all of the imagery. Actually, you have got more windows than you have in a submarine.

The beauty of this tech base is once you put it down it stays down, 24 hours a day. So instead of an up and down every day, holding your breath for 3 hours of work for maybe two scientists, you can put a system into the water and commit it, and leave it there 24 hours a day, and have as many scientists as you want in the expedition.

In fact this summer, we will be experimenting with controlling this robot, and this mechanical arm from Woods Hole, actually operating the ROV system and picking up samples with scientists on the beach, which is a tremendous economic savings, not to take these people out to sea, because it costs a lot of money to take those guys out and have them sit around for a month to spend 3 hours down.

Well, the point is that once you are able to create a simulated presence here, you can create a simulated presence anywhere. So, we were on this, merging—this was what the project was all about that led up to the discovery of the Titanic. It was a Navy development, of Office of Naval Technology and ONR, development of a new exploration technology base, and we just happened to go out in the course of that development effort and find the Titanic.

From finding the Titanic I got introduced to kids on a wholesale basis, and then I saw the problem, and then we said, all right, let's do this. Let's go out to an exciting place, and that's what we did.

We went out in the Mediterranean last year, and we went along the ancient Roman trade routes. Because of the deep sea—and I do not know if you remember my testimony on the Abandoned Shipwrecks Act—but the deep sea is a preserver of man's history.

There are more historical objects in the deep sea than all the museums of the world. Now, for a long, long time those objects have been safe, but now, because of this emerging tech base, we are now throwing the doors open to the deep sea.

The Argo/Jason system can go to 20,000 feet. That means they can reach 98 percent of the world's ocean floor, and the question is, now that we have thrown the doors open to the deep sea, does mankind go through those doors to appreciate or to plunder?

And you remember the whole controversy we had on the Titanic, where we asked this committee, and went on to the Floor of the House and into the Senate, and got the President to sign the Titanic Memorial Act of 1986 which forbid Americans from desecrating the Titanic. Unfortunately, high seas, other nations chose not to view it that way, went out and began plundering the site.

Well, we are going to have that problem back in this room every day for the next several decades as significant pieces of history are found in the deep sea by this emerging tech base. You know, they just recovered that black box off South Africa. From 16,000 feet they brought up the black box.

So the deep sea is now accessible but there is no regime covering it, particularly as it deals with human history. So another part of this project is to make people aware of what we are now doing.

So, anyway, we went out into the Mediterranean, in international waters, and we found a Roman fleet that had been lost in the 4th Century A.D., and sitting, unburied but just sitting there. Now the wood is gone but all the artifacts are sitting there.

We also went a few miles away, on a big volcano that had never been explored—a big volcano, never been explored—and we found that volcano to be active, and had hydrothermal vents, and animal life just like we found off the Galapagos.

So what we are going to do in the next few weeks is, we are going to go back to those two sites—that Roman site and that volcanic site—and we are going to begin exploring them because we left them largely unexplored for the kids. So that it is basically unexplored sites. We know they are good sites but they are pretty much still unexplored.

We are going to begin working. I am going to transmit up here, and married to our control center, National Geographic and Turner Broadcasting have a full television production center, just like NBC, ABC, or whatever, married on to our control center.

They will then begin creating material for the kids. They will then hand that material over to another van next door manned by EDS, and then EDS has a live satellite broadcasting capability with a gyro-stabilized antenna, and it is going to zap up to a satellite called the PANSAT satellite over the North Atlantic Ocean down to Turner Broadcasting in Atlanta.

And in Atlanta, and alsc down into EDS in Dallas. They will then package the programs and transmit it up to another satellite in synchronous orbit, and then down to 12 museums, and in those 12 museums will be a complete replica of our control center at sea. An identical replica.

So when people walk down the street here at 17th and M to Explorer's Hall at National Geographic, anywhere between May 1st and May 14th, you will walk aboard our ship. A two-way hookup. Now then what we did is we went to where the problem was, and after we got this big "carrot" all developed and funded primarily by the private sector, because of their concern, with a huge "carrot" we then went to the national science teachers, and said, "How would you like to take your kids on a field trip that will really cause them to buckle up?" And they naturally said fine.

We then went with them to the National Science Foundation and got funds to develop a curriculum in science and technology, 54 lesson plans, this thick, and said you want to go on this field trip, you send your teachers, 4000 of them, to our 12 sites, and we are going to train them, and we are also going to teach those science teachers some science.

And then we will send those 4000 science teachers out into the hinterlands, and they signed up 300,000 kids, and they are now

teaching them. If you go around here, in Washington, D.C., I think we have here in Washington 20,000 kids getting trained, in this area right here alone, to go on that field trip, and they have signed up for an hour slot.

And they are going to go in, and for one hour, they are going to be with us, exploring the Mediterranean. And the message here is not so much oceanography, which we are all proud of and want to promote, but it is the value of oceanography to the problem, and that is what I think the committee needs to be thinking about. Oceanography is a valuable asset in this war for illiteracy because it is such an exciting field, but doggone it, don't make them marine biologists. We need more marine biologists like a hole in the head. We need physicists, chemists, mathematicians and engineers to fill the ranks of industry to prepare this Nation for a competitive game without war, and that is where we are.

And more important, too, is this network. Now that we have—see, what I did is, I forced the museums to buy the asset. I forced them to buy this control center and so they have—now they are stuck with it. And now they want more programming, because each of those museums filled those 300,000 seats in less than a week. So now they want to go back.

So next year we are going to broaden, we are going to go to the Great Lakes, we are going to work on two ships from the War of 1812 that were sunk in a storm, and those two ships called the Hamilton and the Scerge [phonetic], are in mint condition, sitting on the bottom of Lake Ontario.

We are also working in Lake Champlain. We think we might have located Benedict Arnold's gunboat. When the British shot it out from underneath him, maybe that is what convinced him to go to the other side. We are going to go there, and we are going to begin broadcasting there. But the museums are already saying, "Give us more material." So what we are going to see is, the museums are going to become very important educational centers, and one of the neatest things about museums, that I discovered in this whole game—museums are entrepreneurs. See, if you are in school the truant officer delivers the kids to the door. You have got to go to school. No kid has to go to a museum, and if a museum cannot bring people back time and time again the museum would close. So they are very entrepreneurial. They are out there, as private sector, wooing people into their museums.

And so I see them playing a very valuable role in educational stimulation while this technology base matures. Eventually, simulated travel will go from the museums to the cinemas to the homes, and eventually people will have simulation centers in their homes and be able to travel and have educational experiences.

But that is really the thrust of what we are trying to do. As I said, the ship has left England, and will be transiting down to Gibraltar. I get on it in a few days. We are going to give this a shot. We have got a lot of partners in the process. It is a beautiful marriage of what America is all about as far as industrial capability, its technology capability, educational capability, and the ability of Americans to dream and translate those dreams into reality, and have an impact.

And what is so fun about this project is that it is not written in stone anywhere. This is just a grassroots thing that a lot of us started to do in a concept of volunteerism, and I think that is a very valuable thing to emphasize. One way of solving the budget is not to charge money. And a lot of people are giving their services. I would say there is more free services being put into this project than paid for. We have a network of thousands and thousands of people who have taken this project on as an investment in their kids' education, and so on. That is sort of the formal comments I wanted to give, and I would be more than willing to answer any questions, and predict where we might be going in the future, but hopefully, next year, we will have 30 cities wired up.

We have 12 cities this year. We set that as the limit just because going from zero to 12 was a heck of a jump. We have museums now, across the United States, who want in this network, and it is not expensive. This is what is important. The costs. If EDS and the other groups had not picked up the tab, and the museums had to bear the tab for this one-hour experience, it turns out to be less than $3 a kid, less than a kid pays for an hour show.

So the real economics are going to drive this, and you are going to see, I think, more and more networking of this technology base. Thank you.

Mr. HERTEL. Thank you, Doctor. So 300,000 students, and the cost of the total project is less than $1 million?

Dr. BALLARD. No. Well, it depends on how you look at contributions of in kind. The actual expedition costs $1.5 million. That is the actual ships and robots, and people at sea. But most of these experiences in the future need not be oceanographic experiences. It is an expensive experience in comparison to taking kids to the Grand Canyon, live.

The museums are already realizing they now have the ability to network kids anywhere, and the satellite cost—for example—a domestic satellite—maybe EDS can back me up—the domestic satellite we are using is only 500 bucks an hour.

So once you get up on that satellite, anyone can pluck off of it. So the economics to use that satellite is $500, shared by an incredible number of people, so the costs really go down.

In the Lake Champlain and Lake Ontario effort next year, up in the Great Lakes, we will be using microwave. We will microwave it ashore and then bounce up to the satellite and down. But when you look at the dollars, it is not many dollars.

A simulation center for a museum costs $120,000, which is not a lot of bucks.

Mr. HERTEL. Well, you are very clear on why it is important to target students of that age, because that is when they are reachable and also making their decisions. We also have to educate the adults, so——

Dr. BALLARD. Well, 75 percent of the shows are for kids; 25 percent are for older kids.

Mr. HERTEL. We have got a great job in educating the public, and especially the Congress in this area, too, so that they can better develop the resources in these areas. So we would like to ask that when it is at the National Geographic in May, that maybe we can get an hour or so, that we can invite the Congress and the staff.

Dr. BALLARD. We would love to have all of you come. There are people in the room that can make that happen. We have reserved a number of seats on this rocket ship for people between May 1st and May 14th. We would love to have you there. I would love to say hello. We will have a two-way hook-up. You can ask me some more questions then. We are going to try to get the President to come. He is the educational President—here are the masses, right in front of him—to get him to give a message to the kids.

We are going to try to arrange that. I think it would be a really good message for him to send to kids at this time. We are going to have naval officers out there on the cruise. I think you are going to see a real good cross-section of America participating in this endeavor.

Mr. HERTEL. Well, we think it would be a key project for the President because of his emphasis on the environment and education.

Dr. BALLARD. Exactly.

Mr. HERTEL. To tie it all up together.

Dr. BALLARD. Right. Most people do not realize the oxygen we are breathing today is mostly thanks to plants of the ocean, not plants on land. Most people think all the oxygen you are breathing come from trees, and the vast majority of the oxygen you are breathing in your lungs at this moment came from the ocean.

And the problem with that membrane of life in the ocean—and it is a very thin membrane. There is not much life at depth. Most of your life is in a very thin membrane, and that membrane is connected by water molecules, and it is a lot easier to pass pollutants and toxins through water than on land.

And so the biggest concern I have is not the mineral potential of the sea, or anything like that at all. My biggest concern is, are we going to kill that membrane that is providing me my oxygen—and I want to keep an eye on that— and the waste that we are dumping into the sea has that potential.

Mr. HERTEL. The subcommittee shares your concerns. Questions from the subcommittee? Mr. Saxton.

Mr. SAXTON. Dr. Ballard, this is a very enjoyable and impressive set of circumstances that you have brought to us, and your project is certainly something that has a great deal of interest to us as members of this committee, and I am sure would be of interest to most any member of Congress who was oriented toward the environment and the ocean, and has the same kind of concerns that we do.

And your application of this technology for educational purposes seems to me to be most worthwhile, and we congratulate you for emphasizing that. At the same time it appears that there would be a great many other uses for this technology.

Dr. BALLARD. Very much so.

Mr. SAXTON. By industry. Perhaps by the oil industry and perhaps by many other industries that are not even exploring or using the ocean resources that we have available to us. And in addition to that, many of us have concerns about the environment as related to the ocean, and what we have done to it, and I can well imagine that there are many uses for this technology with regard to the

clean-up efforts that many of us are interested in with regard to the ocean.

I am thinking of the sludge problem that we have off the New Jersey coast, and whether the scientists that are studying it are having some difficulty in determining whether or not it is harmful, and if it is harmful, how harmful is it.

We feel that the preponderance of evidence indicates that it is harmful. We just cannot prove it. Certainly, this technology could be helpful in that regard.

Would you expound, to some degree, on other uses such as this?

Dr. BALLARD. Oh, very much so. I should point out that I am a commander in the United States Navy Reserve, very active in the Navy, and certainly, the Navy is well aware of—they funded it, and they are very well aware of its potential, not only for basic research—Office of Naval Research and Office of Naval Technology have been the real stalwarts in the providing of deep submergence technology over the last 25 years.

They built, funded the Alvin, realizing its value, not only for basic science, but in search and recovery. People continue to lose things in the ocean, both us and others, and there is a desire on the part of a whole variety of communities to take advantage, or to recover things that are lost. So the Navy is well aware of that.

Actually, quite honestly, the hardest customer we are trying to convince is our own oceanographers. Scientists tend to be extremely conservative in the acceptance of technology. We figured if we educated their kids first, we might have a shot at them, but this presentation is directed at the National Science Foundation and other organizations that sponsor the funding of technology and its utilization.

So we are hoping that the oceanographic community will realize the value of this for basic exploration, basic research in the sea, both in a basic research sense and certainly in an applied sense.

We have been approached by organizations that are looking at the potential of using the deep sea's dump sites for low-grade radioactive material, or for sludge, sewage, and we do not know enough about the environmental environments down there to really give an honest answer.

Your gut reaction is water moves things very efficiently, and there is a tremendous gut reaction—don't put it down there.

Mr. SAXTON. Let me, if I may just interrupt for a minute, because you have reminded me of something that I have been involved in to some extent. During World War II, or following World War II, apparently the Navy decided to dump some types of munitions off the coast of Cape May, and they are out somewhere between a 100 and 200 miles—I have forgotten the figures—and they are in 5000, 6000, or 7000 feet of water.

Is a practical application of Jason to explore, to see whether or not that has done any damage to the environment?

Dr. BALLARD. Oh, that is very easy. Yes. It is very easy to—now, with this tech base—to locate and monitor sites. I have done work for the Navy at Navy sites, and certainly there are environmental sites that could be easily monitored with this technology. The beauty of it is the expense rate. I mean, you can transmit your data via satellite back to the beach. You do not need to have a

highly trained staff at sea. You can have them on the shore. I think we are going to have a tremendous impact where—if you just look at the economics of a scientist going to sea.

I mean, take a Ph.D. and look what you are paying him. Put him on a ship that goes 10 miles an hour to go out to a place. Sits there over the site. You look at the average time a scientist on a manned submersible actually spends in a submarine on a month-long expedition. So the person is out for a month and he gets six hours on the bottom.

You calculate what that costs you in human resource. Take that Ph.D., train him, get him ready, get him out there and use him for six hours. He could just go to the lab at 11:00 and make his trip, and do his thing, and then go back to teaching or whatever.

And I think that we are going to see that emerging. I think it is going to be pervasive. This technology base I found—I did not invent it—and I found it not in the ocean. I found it out in the telecommunications industries, out in that area.

And I think we are going to see the impact of electronic travel. I venture to say that in several years you will have hearings here, and you will think I am here but I am not.

And you will have access, you will have access to a lot more people. You will not always get them from the East Coast; you will get them out West, too. Because you will have a hearing room where you have a simulated—a person looks like he is there, and you have the sense that—it is not like a television where you wonder what is going on in the room, and you wonder if they have got their attention. You do not feel that you are communicating at the level that you need to communicate.

Mr. SAXTON. We will beam you right in, Scottie.

Dr. BALLARD. Exactly; exactly. That tech base, the kids are already prepared for it. But what I have found is the scientists are the hardest ones to convince. They are real set in their ways.

Mr. SAXTON. Thank you.

Mr. HERTEL. Mr. Goss.

Mr. Goss. Thank you, Mr. Chairman. I am very happy to be here. I apologize for coming in late. My interest is Mote Marine's participation in this, and we have been working on many of the things that you say we are going to be able to work on better with this equipment, and have a better audience for it, and that, to me, is all good news. So that is my reason, and I want you to know you have got a friend in Florida.

Dr. BALLARD. Well, we are glad that Sarasota joined the net, and I have been working with the Mote Lab. They are a marvelous group of people, and really in the battlefield, right now, of the environmental issue, and I am sure you have got good people at your fingertips when you need good advice.

Mr. Goss. Well, thank you for the kind words, we think so, too, and with your help we are going to be even better.

Dr. BALLARD. Well, I think we have got now, in Sarasota, 20,000 kids are signing up to network in.

Mr. Goss. There is no shortage of interest, that is for sure. Thank you. Thank you, Mr. Chairman.

Mr. HERTEL. Mr. Herger.

Mr. HERGER. No questions, Mr. Chairman.

Mr. HERTEL. Can I ask another, on another issue. Dr. Ballard, we are going to be having hearings on the NOAA fleet. I know it is more expensive, but what about including submersibles in the NOAA fleet in the future?

Dr. BALLARD. I honestly, having spent 25 years of my life in manned submersibles—I suspect I have been in those more than anyone in the world—I would not put a dime in them. They are gone. They are going to be in museums.

Mr. HERTEL. Too expensive and the capabilities not good enough?

Dr. BALLARD. Yeah. It is just not worth the bucks. I mean, if you—we have manned submersibles—it is sort of like the definition of a paradigm. I hear some guy give a beautiful lecture on paradigm. A paradigm is a model that you are living under, and then there is a new paradigm that always replaces the old paradigm. And he had, really, a very convincing lecture I heard last week, where he says, you know, the new paradigm begins when you are at the peak and you are really moving on the present paradigm, and that is when the data is there to tell you there is something better. But most people wait for that paradigm to flatten out, and then they move to the next one.

It is very clear to me, that the paradigm we are talking about started 5 years ago, and even though manned submersibles are still looking good, they are "goners," and if you have got one you can still get a lot out of them.

I think that the Alvin program and manned submersibles that presently exist are well worth it because they are on their peak right now, but to begin investing in a new one that will take 5–6 years for that thing to come on line, is a waste of money as far as I am concerned. I am sure I just drew some fire on that, but I happen—that is what I believe.

Mr. HERTEL. What about using Navy submarines in this area?

Dr. BALLARD. Well, there are several Navy submarines, particularly the Sea Cliff and the Turtle which are based in San Diego. Sea Cliff is a 20,000-foot asset. It is the only submersible we have got in the technology that can match the Soviets' 20,000-foot submarines. It is the only asset we have got. Until we can bring these new emerging technologies on line, the Sea Cliff and the Turtle are critical.

Also, my favorite submarine is the NR–1, not so much as a research platform, and I will put on my Navy hat. The NR–1 is the only nuclear submarine the Navy has ever built that loves the bottom of the ocean.

One of the concerns I have with my colleagues in the Navy is that I believe the Navy of the future is going to be a terrain-involved Navy that utilizes the mountain ranges we are discovering down there.

It is amazing that the largest mountain ranges on our planet are beneath the sea, and we stay away from them, militarily, because they are all mean and rough, and dark and dirty. And I believe that, particularly up in the polar regions, that terrain is an asset.

Now that is because before I was a naval officer I was an army officer. But I have a great deal of respect for the bottom of the ocean, and I see the NR–1 based up at Groton as a prototype sub-

marine of the future, and I spend a lot of time and energy with that particular platform.

But conventional ballistic—I mean ballistic missile submarines or fast-tech submarines, they have their role, but not in basic exploration. But the Navy do have assets that are valuable to basic exploration—Sea Cliff, Turtle, NR-1.

Mr. HERTEL. What about the Navy's role in using non-manned submersibles?

Dr. BALLARD. Again, they sponsor the Argo/Jason program. The Navy is really the pioneer, right now, in unmanned vehicle systems in the deep sea. There is a lot of activity in the oil patch, or was a lot of activity. Unmanned vehicles really started in the oil patch. It began with the initial replacement of divers to work on rigs in the North Sea, and off the Texas coast, California coast, moving away from using physical people.

If you know the history of that, it went from diving, scuba diving to mixed gas, from mixed gas to habitats, but still the cost was prohibitive, the risks were prohibitive. Insurance companies were taking them to the cleaners.

They moved away from that to lockout submarines. We had a proliferation of lockout submarines in the industry, but now, they are the ones that began the ROVs, the remotely operated vehicles.

We have taken that tech base from 2000 feet and taken it to 20,000 feet, but that has been funded by the U.S. Navy. So the Navy is on top of it. As far as are they aware of it, yes. And are they utilizing? Yes. But have they implemented that technology in warfare? No.

Mr. HERTEL. So is it funded adequately, I guess is my point? Could they do more with the potential, if they had increased funding?

Dr. BALLARD. I think that the Navy is taking a hard look at its assets, and its assets on line. It takes a long time to bring those big assets on line. You just do not turn around and say, you know, I think you ought to do it another way, and you have got a 20-year asset development on line. But what they are——

Mr. HERTEL. Well, the Air Force, and even Navy, does that sometimes, you know.

Dr. BALLARD. Yes, but what they are doing, which I find encouraging—for example, they are beginning to look at their torpedo tubes as things that do not just send torpedoes out of them. They are beginning to look at their torpedo tubes as things you put vehicles out of, where you can force multiply.

So yes, they are looking at that, and they are sponsoring programs like that. It is just it is a big outfit, and once it gets going along a track, you have to work on deflection as opposed to right-angle turns.

But we are working, we are pounding on it. I go today, and I will be with Admiral McKinnon, giving him a briefing on my concepts of terrain warfare, and Admiral DeMars, and Admiral McKee, before he left—very sharp people—Admiral Trost is sharp on these issues. The submarine community is sharp on the issues. It is a question of how much maneuvering room do they have.

Mr. HERTEL. Well, we want to thank you very much, Doctor, and wish you, and all of the people with you, great success and safety in the Jason Project.

Dr. BALLARD. Well, thank you very much. A pleasure. I hope you will come down and say hello at 17th and M.

Mr. HERTEL. We will. In fact we will try to convene the subcommittee there. Thank you.

Dr. BALLARD. Thank you.

[Whereupon, at 1:07 p.m., the subcommittee was adjourned, subject to the call of the Chair.]

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